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M I N U T E S   A N D   P R O C E E D I N G S

of the seventeenth meeting of the

ARMY - NAVY - NRC VISION COMMITTEE

14-15 October, 1946

Fort Dix, New Jersey

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MINUTES

Seventeenth Meeting
Fort Dix, New Jersey

14-15, October, 1946

The following were present:

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AAF — Col. A. J. Jennings, School of Aviation Medicine, Randolph Field, Texas

AGO — Dr. Edwin R. Henry
Dr. Douglas Fryer
Dr. Robert Wherry
Dr. Donald E. Baier
Dr. Donald Sisson
Dr. Erwin K. Taylor
Mr. Lawrence Karlin
Dr. Horace Corbin

QMG — Mr. John C. Rich

Research & Dev'mt Division — Col. E. N. Kirsten

NAVY

BuShips — Comdr. Dayton R. E. Brown

NRL — Dr. E. O. Hulburt

ONR — Comdr. H. Gordon Dyke
Dr. Henry A. Imus

Sub-Base — Captain C. W. Shilling
Lt. Comdr. Dean Farnsworth
Lt. Comdr. Ellsworth Cook

NRC — Dr. Franklyn D. Burger
Dr. Clarence H. Graham
Dr. H. K. Hartline

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Dr. Kenneth N. Ogle
Dr. W. S. Verplanck
Dr. D. F. Windenburg
Dr. Donald G. Marquis
Mr. H. Richard Blackwell
Maj. Gen. W. W. Eagles, Fort Dix
Col. Austin Lowrey, Jr., Walter Reed Hospital, Washington, D. C.
Comdr. L. V. Julihn, Office of Public Information, Wash. D. C.
Dr. Helen C. Dodd, Philadelphia Quartermaster Depot
Mr. Raymond Stegerman, Scientific Bureau, Bausch and Lomb Optical Co., Rochester.

[redacted]

Monday Evening, October 14, 1946

1. The Chairman called for corrections or alterations in the Minutes and Proceedings of the 16th meeting. There were no corrections. The Chairman asked that a correction, submitted in writing by Dr. Chapanis, be read into the Minutes. Dr. Chapanis asked that his comment on Page 46 be amended as follows:

   Dr. Chapanis observed that the ordinary daylight varies enormously in color temperature and that these differences in the color temperature of ordinary daylight would probably produce greater variations in color discrimination than would the use of such slightly tinted sunglasses as the Army Air Forces rose smoke or green. Dr. Chapanis feels that this point is an important one which has been largely overlooked in laboratory experiments on this general problem. To continue the argument, he states that if fliers can perform equally well under the rosy glow of morning skies and the blue-whitish cast of noon skies--as they appear to--he is inclined to question the validity of the conclusion that sunglasses <u>must</u> be strictly neutral.

2. Captain Shilling welcomed the group and described the background of vision research from which the present project developed.

3. Research Program No. <u>PR-4075:</u>
   Its organization and purpose: Dr. Douglas Fryer.

   The Chairman requested that an introductory statement of the aims of Research Program No. PR-4075 be read into the Proceedings - 11

4. Inspection of research facilities: Dr. Horace Corbin.

Tuesday Morning, October 15, 1946

5. Observation of scheduled routine vision examination: Directed by Dr. Horace Corbin.

6. Observation of standardizing measurement of illumination of the examination room: Directed by Mr. Lawrence Kerlin.

7. The Chairman requested that a description of the plan for Project PR-4075 be read into the Proceedings - - - - - - - - 25

8. Conference with examiners and attendants of Project Staff: Directed by Dr. Douglas Fryer - - - - - - - - - - - - - - - - 25

Tuesday Afternoon

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INTRODUCTION

1. History and Scope. The establishment of Research Program No. PR-4075 was the result of a wide-spread conviction that vision testing in the military services needed to be subjected to further study and standardization. This conviction led the Office of the Air Surgeon, supported by the Office of the Surgeon General, to issue a memorandum to the Assistant Chief of Staff G-1, U. S. Army, calling for the establishment of a research program within the Office of the Adjutant General. An excerpt from the memorandum, dated 25 September 1946, follows:

> "During the past few years certain inconsistencies in the established physical standards for aircrew training have become evident. The demand for large numbers of trained individuals, however, prevented any change in these standards. In an attempt to correct the various inadequacies in the physical standards and to provide some basis for uniformity of testing the various criteria, the Army-Navy-OSRD Vision Committee established a subcommittee on Procedures and Standards for Visual Examinations. This committee is composed of various members of the military and Navy establishments, including a member of this office.
>
> "The first problem to be tackled was the testing of visual acuity. It has been evident to all concerned with this problem that the method of testing visual acuity varied greatly between the services, within the services, and, as a matter of fact, from day to day at the same facility. This incongruity in testing this basic visual function in many instances evoked great hardship on an individual, interfered with training schedules, and, consequently, cost the Government a considerable amount of money. For example, an individual might be accepted for aircrew training with the notation that his vision is 20/20. On an examination just prior to commissioning, his vision is again tested and might be found to be 20/40 or less. This entailed disqualifying the individual for commission and resulted in a loss to the Government of the amount of money expended for his training.
>
> "The Subcommittee on Procedures and Standards for Visual Examination of the Army-Navy-OSRD Vision Committee has prepared a manual on the testing of visual acuity and also has prepared 4 or 5 vision test charts. These charts have received preliminary testing at several military establishments. It is

hoped that as a result of the work of this committee, a standard procedure and standard charts for testing vision may be available to all units of the armed services. This will naturally enhance the value of any such tests in that the variation in visual acuity brought about by changes in the physical set-up and method of testing from establishment to establishment will be reduced to a minimum.

"The Air Surgeon has been informed that the Classification and Replacement Branch of the Adjutant General's Office is prepared to conduct field tests on this problem."

The problem was assigned to the Personnel Research Section, Personnel Research and Procedures Branch of the AGO. Dr. Edwin R. Henry, Chief of the Section, immediately called upon the Army-Navy-NRC Vision Committee for assistance in setting up the program. A meeting of an appropriate subcommittee was held in Ann Arbor on December 11, 1945. Through this meeting and subsequent conference and correspondence, the Committee contributed to the design of the experimental program.

II. General Plan. The first broad objective of the research was the development of reliable tests to isolate each of several basic visual capacities. The second general objective was the standardization and validation of these tests for certain military jobs. The first step was to pool scientific information and opinion concerning the most likely isolable visual functions and the most promising tests for measuring them. This was accomplished by the coordinated efforts of the Personnel Research Section and members of the Vision Committee. Plans were then made for the initial experimentation which would involve administering the selected tests to a rather large military population. Analysis of the data obtained would indicate the reliability of the tests chosen and their adequacy in isolating visual capacities. Refinements in tests to increase their reliability and factorial uniqueness would then be undertaken. Supplementary investigation of various methodological questions might well be necessary in this connection.

In order to conduct the initial experimentation, decisions were required concerning the experimental procedure to be used in administering the tests under investigation. Again, these decisions were made as a result of the coordinated work of the Personnel Research Section and members of the Vision Committee.

The development of a number of new tests was found desirable. In producing pilot models of these tests, Lt. Comdr. Farnsworth and other members of the Naval Medical Research Laboratory, New London, contributed a great deal of time and effort. The Bausch and Lomb Optical Company, especially Mr. Fred Jobe, was very cooperative in producing charts for the new tests. The Vision Committee assisted directly in procuring some of the test charts to be included in the first experimentation.

The Personnel Research Section set up the first experimental run at Fort Dix, New Jersey. At the invitation of the AGO personnel, several members of the subcommittee of the Vision Committee inspected the Fort Dix installation. Various valuable suggestions resulted from this meeting.

All arrangements were completed, personnel was trained, and experimentation was begun on October 1, 1946. The meeting of the Vision Committee at Fort Dix on October 14-15 was arranged to allow the members to observe collection of the experimental data at first hand.

The first experimentation will be completed by November 15. In order to plan for the next phases of the program, the subcommittee of the Vision Committee and members of the Personnel Research Section are scheduled to meet in New York on that date.

PLAN FOR FIRST PR-4075 EXPERIMENTAL RUN*

I. Test Rooms. The test charts are viewed in a special room, constructed to provide uniformity of testing conditions at the various installations at which experimentation will subsequently be conducted. In conjunction with each testing room there is an adaptation room where the subjects remain for ten minutes prior to testing. Specifications for the test rooms to be used at all installations for future testing are as follows:

A. Waiting Room. The waiting room will be located near the testing room and a light-proof passage provided between waiting room and testing room. The waiting room shall be in conformith with the following specifications:

1. A centrally located overhead lamp (100-watt) inclosed by a blue-white diffusing globe and shielded by a backdrop from the direct vision of the examinee. This will be the only source of illumination in the room.

2. Windows shielded from the direct vision of the examinee.

3. All sources of glare eliminated.

4. The walls at four feet height not less than 2 nor more than 5 foot candles as measured by the General Electric Exposure Meter at right angles to the surface with the examiner standing to one side.

5. Six chairs provided for waiting examinees.

6. Fan on pedestal located to circulate the air of the room.

B. Testing Room. Each testing room will be located in an absolutely light-proof surround where no disturbance from other testing rooms or other source will interfere with test procedure. The construction of the testing room and the arrangement of equipment will conform in every respect to the specifications given on the next page.

*Described fully in: Progress Report, Project No. PR-4075, AGO, Personnel Research Section, 1 July 1946, (R)

1. SIZE. The testing room will be 10 feet wide, 25 feet long and about 8 feet high, all inside dimensions. The ceiling and walls will be made of a special diffusing reflection cloth provided by the Personnel Research Section. This will be stapled to the inside of the framework in such a manner as to provide the smoothest surface possible. In installing this cloth, care must be taken to keep it clean.

2. LIGHTING. Two 200-watt lamps will be suspended directly from the longitudinal crossbar of the framework at distances of 3 feet 5 inches and 21 feet respectively from the front of the testing room, and one 300-watt lamp will be suspended in the same manner at the center of the testing room. Each lamp will be inclosed by a blue-white diffusing globe (not clear glass). Each of the two lamps nearest the front wall of the testing room will be shielded from the direct vision of the examinee by a drop placed 4 inches behind the lamp. The drops will be made of a triple thickness of the cloth provided, suspended in a frame directly from the ceiling and dimensioned as follows:

   length - full width of the testing room
   width - 5 inches below bottom of lamp globe

3. An apparatus is provided to change the charts automatically, operated by the examiner at the touch of a button. The chart changer is placed just outside the <u>front</u> wall of the testing room so that the chart holder protrudes slightly through a hole cut in the cloth forming the wall. This hole is 13 inches wide and 21 inches high, is centered from the sides of the room, and so cut that the center of the test chart which protrudes through it is <u>exactly</u> 4 feet from the floor.

4. LIGHTING CONDITIONS.

   (a) A blank white card in the place of the charts will average 12 foot candles and shall not be less than 10 or more than 15 foot candles as measured by the General Electric Exposure Meter, readings being taken at right angles to the surface, with the examiner standing to one side. There must be no shadows, flickers, or reflections.

   (b) The walls of the testing room at a height of 4 feet shall nowhere be less than 3 foot candles nor more than 8 foot candles as measured by the General Electric Exposure Meter in the manner indicated above. There must be no noticeable spots of glare or shadow within the examinee's field of vision.

5. FURNITURE. A chair and headrest will be provided for the examinee. The seat of the chair will be of standard height (18 inches above the floor). At a distance of exactly 20 feet from the rear wall in the center of the room, a mark will be made by which to locate the base of the headrest. The mark on the base of the headrest will then be aligned with this mark and headrest secured to the floor. The headrest should then be in position so the examinee's eyes are 20 feet from the test chart. A table and chair shall be placed to the left of the examinee so that the examiner can observe the examinee's eyes and show him the illustrative hand charts.

6. VENTILATION. Two fan pedestals will be mounted approximately four feet from the rear of the testing room at a height of 6 feet 6 inches. One fan will be placed on each pedestal pointing in such a manner as to insure against agitation of the cloth walls. If the cloth of the rear wall is drawn aside to improve air circulation, the examinee must not be permitted to turn around until the entire examination is completed.

II. Population.

A. Population Characteristics. The sample will be drawn from a reception center population consisting of enlisted men only between the ages of 18 and 29 inclusive. Insofar as possible, an equal number of enlisted men will be selected from each age group within the above range; within each age group, the men will be distributed on recorded left eye vision test (Snellen) as nearly as possible in accordance with the following:

Left Eye Vision Test (Snellen)	Proportion within Each Age Group
better than 20/20	15%
20/20	50%
20/30	20%
20/40	10%
worse than 20/40	5%

B. Selecting the Sample. Approximately 400 enlisted men (33 from each age group) will be examined at the installation. The first 200 enlisted men will be reexamined not less than 18 nor more than 72 hours after the first examination. Because of the three-day turnover in reception center population, it may be necessary to select a new sample for examination about every three days. Each succeeding sample should be selected so that the specifications above are complied with as nearly as possible. A running check should be made to insure that, when the required total number of examinations have been made, all sample specifications are met.

III. Test Charts.

A. The test charts for the Vision Examination are constructed according to two principles: (1) Snellen type units bearing relationship to a theoretical conception of normal acuity, and (2) psychophysical type units bearing logarithmic relationship to visual angle.

The preconceived opinions of normal visual acuity generally held with respect to the Snellen units in the measurement of visual acuity has made it appear expedient for the Personnel Research Section to abandon the use of these units in favor of an arbitrary system completely divorced from any preconceived concepts of normal acuity. It was decided that the physical basis of unit to be used would be the visual angle, and that the AGO visual acuity unit would bear a logarithmic relationship to its physical counterpart, the visual angle. Starting from the assumption that perceivable increments in visual discrimination bear a constant relationship to the point of change and arbitrarily setting this constant at 2, the formula for the derivation of AGO Visual Acuity units was set at:

$$U = (10 - \mathrm{Log}_2 A) \quad \mathrm{Log}_2 \frac{2^{10}}{A}$$

in which U is equal to the AGO visual acuity unit and A is equal to the visual angle. This unit has the property of being positive throughout the normal range of vision and yet describes in small enough units to be easily handled. Visual angles may readily be converted to AGO visual units with the use of a 5-place table of logarithms to the base 10. The following formula may be used for this purpose:

$$U = 10 - \frac{\log_{10} A}{.30103}$$

Similarly AGO visual units may be converted to visual angles by the formula:

$$\mathrm{Log}_{10} A = (.30103)(10 - U)$$

$$A = \mathrm{Antilog}_{10}\ (.30103)(10 - U)$$

B. Charts.

1. Letter Charts. Four letter charts have been used. Although the consensus of opinion was that letter charts would not prove to be factorially unique, their universal use made their inclusion obligatory. Three of the letter charts are modifications of the usual test, designed to improve its reliability. Considerable development work was done on these

charts at the Naval Medical Research Laboratory, New London, and at the School of Aviation Medicine, Randolph Field.

(a) Army Snellen (Figure 1; Test 1). Each letter in a row is composed of strokes of a constant size. The stroke size decreases for subsequent rows.

(b) New London Letter (Figure 2; Test 4). The letters in each row are equated for difficulty and are of equal size and equal stroke width. The size of letters and the width of stroke for succeeding rows decreases from top to bottom.

(c) AAF Letter (Figure 3; Test 7). There are six letters in each row equated for difficulty and of equal size and stroke width. The size of letters and the width of stroke decreases for succeeding rows from top to bottom.

(d) AAF Constant Decrement (Figure 4; Test 10). The size of each letter and width of stroke decreases from letter to letter across each row and from top to bottom of the chart. Each letter decreases one Snellen step in size from left to right and top to bottom.

2. Resolution Tests. There are four resolution tests. Each requires the examinee to report in which of four possible locations the test object occurs. It is essential to the success of these tests that the examinees continue reporting even though they believe it is only guesswork. Only when reporting is continued until the number of correct responses is the number attributable to chance can the tests be discriminating.

In order to teach the examinees the value of "playing their hunches" on this kind of test, a practice test was developed in which the location of the gap in a modified Landolt ring was to be ascertained. (Figure 14) It was hoped that their experience on the practice test would encourage the examinees to continue making correct reports as long as possible, beyond the limit of their own feeling of confidence.

(a) Bausch and Lomb Checkerboard (Figure 5; Test 3). This is the same test used in the Bausch and Lomb Orthorater increased in size for use at 20 feet. It consists of a square grouping of four squares, one of which contains a grid coarser than the other three. The coarse grid

is a checkerboard type made of rows of alternate black and white squares, while the grids of the other three squares in the group consist of rows of black dots. The square with the coarser grid varies in location from figure to figure in chance order. Each group decreases in size from top to bottom.

(b) Checkerboard Variable Grid (Figure 6; Test 12). This test uses the same figure as the Bausch and Lomb Checkerboard Test, except that the figure size remains constant while the individual squares making up the checkerboard grid of the odd square decrease in size for each succeeding row. The checkerboard grid is of constant size for each of the four figures in a row. The location of the square containing the checkerboard grid is distributed in chance order among all the figures.

(c) Line Resolution (Figure 7; Test 8). A line of constant blackness and length extends from the center and points to one of four corners of a constant-sized white diamond on a field of uniform gray. In each row, there are four diamonds, each containing a line of uniform width which points to a different corner of each diamond in chance order.

(d) Dot Variable Size (Figure 8; Test 2). A dot of constant blackness is located in one of four corners of a constant-sized white diamond on a field of uniform gray. In each row, there are four diamonds containing dots of equal diameter. The diameter of the dots decreases from the top row down. The dots are located in the corners of the diamonds in chance order.

3. Contrast Sensitivity Charts.

(a) Quadrant Variable Contrast (Figure 9; Test 3). Each figure consists of 3 quadrants of a constant-sized square similar in shape to an arrowhead. The shade of the figure varies from darker than the background to a shade which almost matches the background. Contrast between figure and background decreases from left to right within a row and from the top row down. The apex of each figure points in any one of four directions horizontally or vertically in a chance order.

(b) Dot Variable Contrast (Figure 10; Test 9). Rows of uniformly gray diamonds of constant size are on a background of uniform white. In one corner of each diamond a gray dot of constant size, always darker than the gray of the diamond, is located. Contrast between dot and diamond decrease in each row from left to right and from the top row down. The dots are located in the corner of the diamonds in chance order.

4. Vernier Acuity Chart. (Figure 11; Test 13). Rows of crosses are used, each having half of one arm displaced. The amount of displacement is the same for the crosses in each row but it decreases with rows from top to bottom. The position of the arm which is displaced varies in chance order.

5. Form Discrimination Charts.

(a) Triangle Discrimination (Figure 12; Test 5). Each figure is made of four parts. These are placed about a circle at 90° intervals, their apexes touching the circle. Three of the parts are equilateral triangles. The fourth part is identical with the others in all respects except that the side opposite the apex is bowed convexly. The convexly-bowed side is constructed so that this part is equal in area to each of the other three parts. The direction of the convexly-bowed side is distributed in chance order among the figures. The degree of convexity is constant for the two figures in each row but decreases between rows from top to bottom.

(b) Square Discrimination (Figure 13; Test 11). The areas of all figures are equal to 1 square inch. Of the six figures in each row, one is not a square. The sides of this odd figure are arcs drawn so that an equal area is maintained for all figures. The odd figure is distributed in chance order among the center four figures in each row. The deviation from squareness decreases from top to bottom of the chart.

C. Experimental Procedure.

1. Examining Staff and Schedule. The field staff for each test unit will consist of two examiners and two attendants. The staff will maintain an examination schedule from the earliest practicable hour in the morning to not later than five o'clock in the afternoon.

(a) Selection of Examiners. Examiners should be carefully selected since they will be directly responsible for maintenance of specified conditions in the Vision Examination Unit, correct examination procedure, and collection of data. It is preferable to select examiners who have mechanical experience but no previous visual testing experience.

(b) Practice Examination Sessions. These sessions will conform in every respect to the regular examination procedure outlined in the Examiner's Manual, except that all Vision Examination Records will be clearly labeled "Practice". All specified conditions will be checked at each Vision Examination Unit, and waiting room procedure as well as actual conduct of the examination will be as prescribed. During these practice examinations, the War Department representative will perform the following functions:

Both before and after the practice sessions for the day, he will meet with all examiners and attendants to answer questions and discuss procedure. He will witness as many practice examination sessions as possible, check compliance with specifications, and correct any deviations from specifications. He will witness at least two of the five practice examinations for each examiner.

2. Testing Procedure.

(a) Coordinating officer obtains medical records for all enlisted men who will be available for at least the following two days.

(b) Select all records within the age range 18 to 29 inclusive, and divide into equal age groups.

(c) Divide each of the age groups equally into five groups according to left eye Snellen score as follows: (1) better than 20/20, (2) 20/20, (3) 20/30, (4) 20/40, (5) worse than 20/40.

(d) Using as a base the number of enlisted men who can be examined within the next two days by the three test units (approximately 40), select for each age group the number of men required from each of the five groups of Snellen scores in the proportions listed above.

FIGURE 1; TEST 1

L

O B

T C L

P L O E

E D T O L

P L C T D E

D T O E C L P

C L D T O E C L

P E Z O L C F T D

FIGURE 2; TEST 4

G N V H Y

V C E K H Y

O X Z V G E K

N C Y Z G X K H

O N C E H N K X

Z G H Z O H C Z

Y E V Y E K C N

O Z H V O X Y C

Z K X V G E N O

C Y V N K E G V

H C Z X K N C E

FIGURE 3; TEST 7

K N G S Y P

N K Y P G S

G P K Y S N

S G N K P Y

Y S P G N K

P Y S G K Z

K G Y N S P

N Y G K P S

G K S P Y N

S N P G K Y

Y P N S G K

FIGURE 4; TEST 1C

V N C

E O Z N V O

Z C V E Z O N C

V E N E Z O N C Z

C V E O Z C N E V O

FIGURE 5; TEST 6

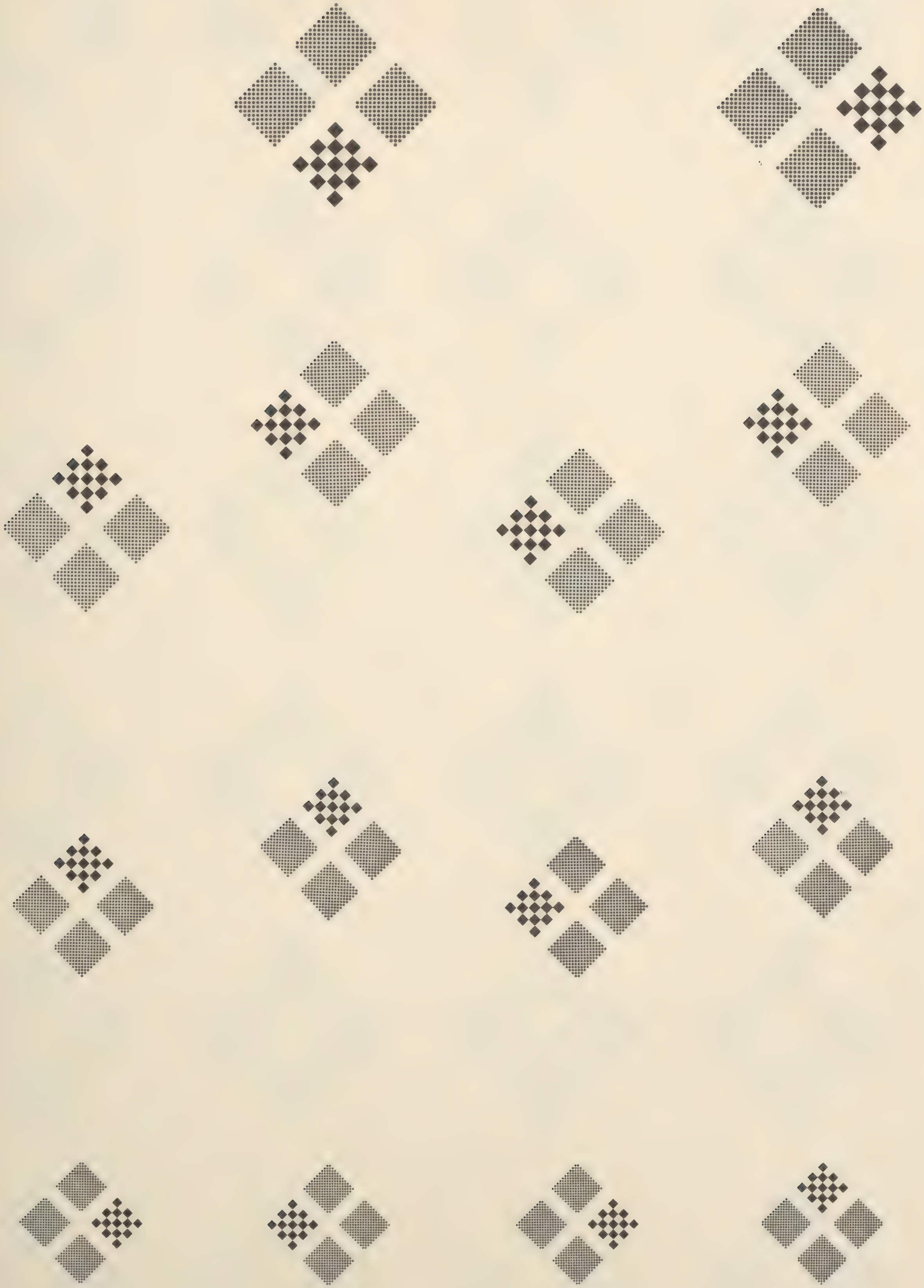
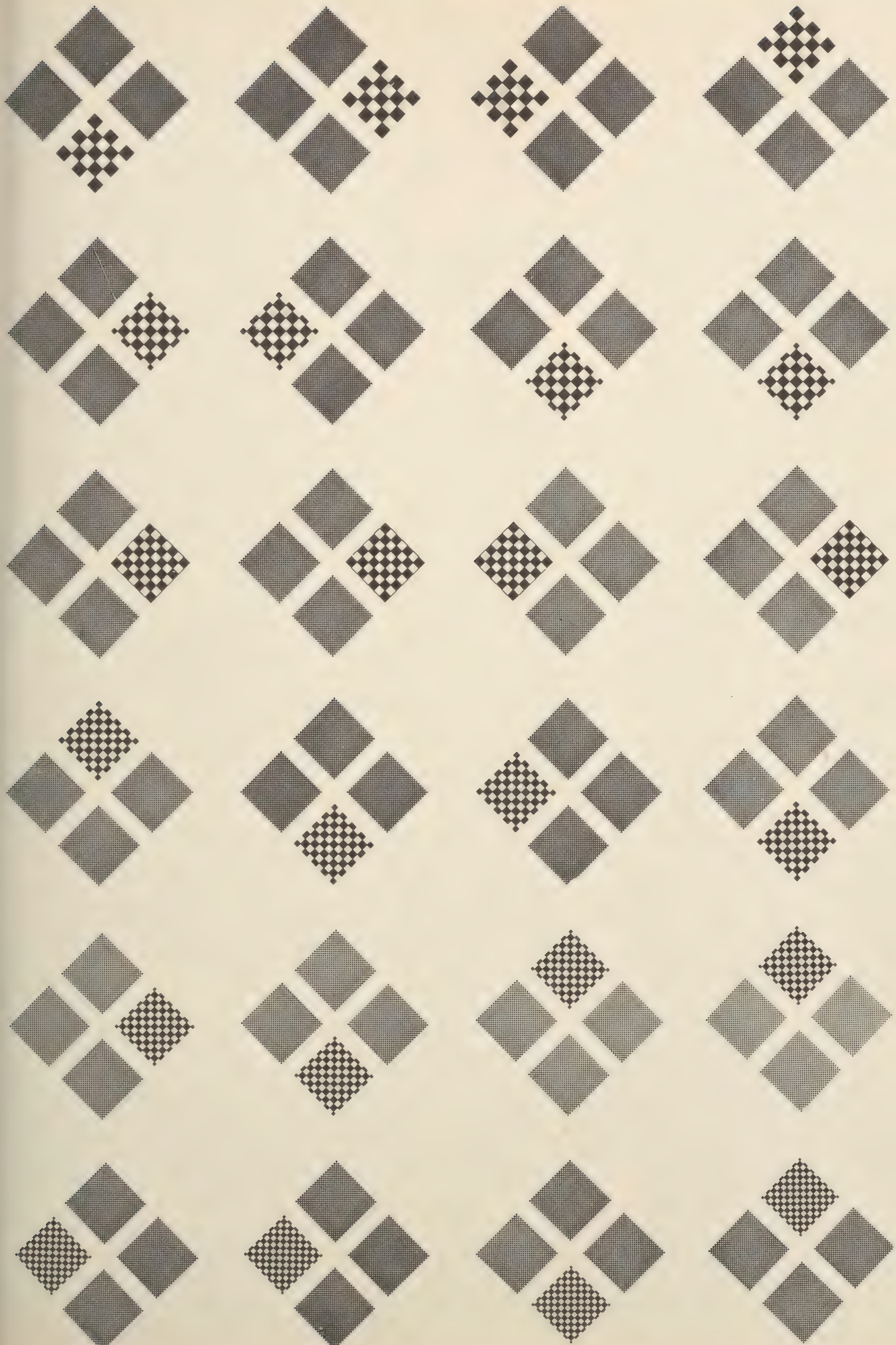
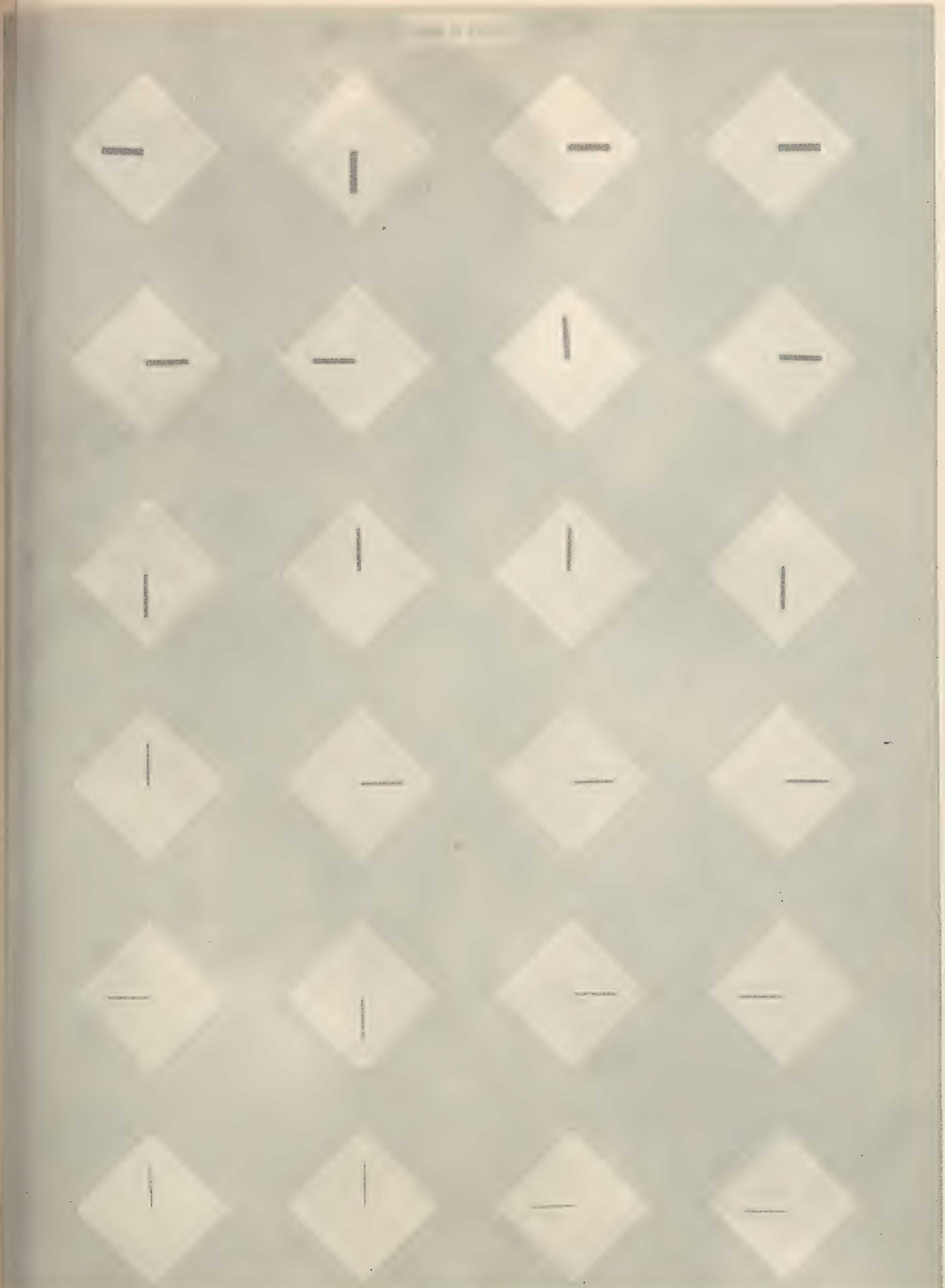


FIGURE 6; TEST 12





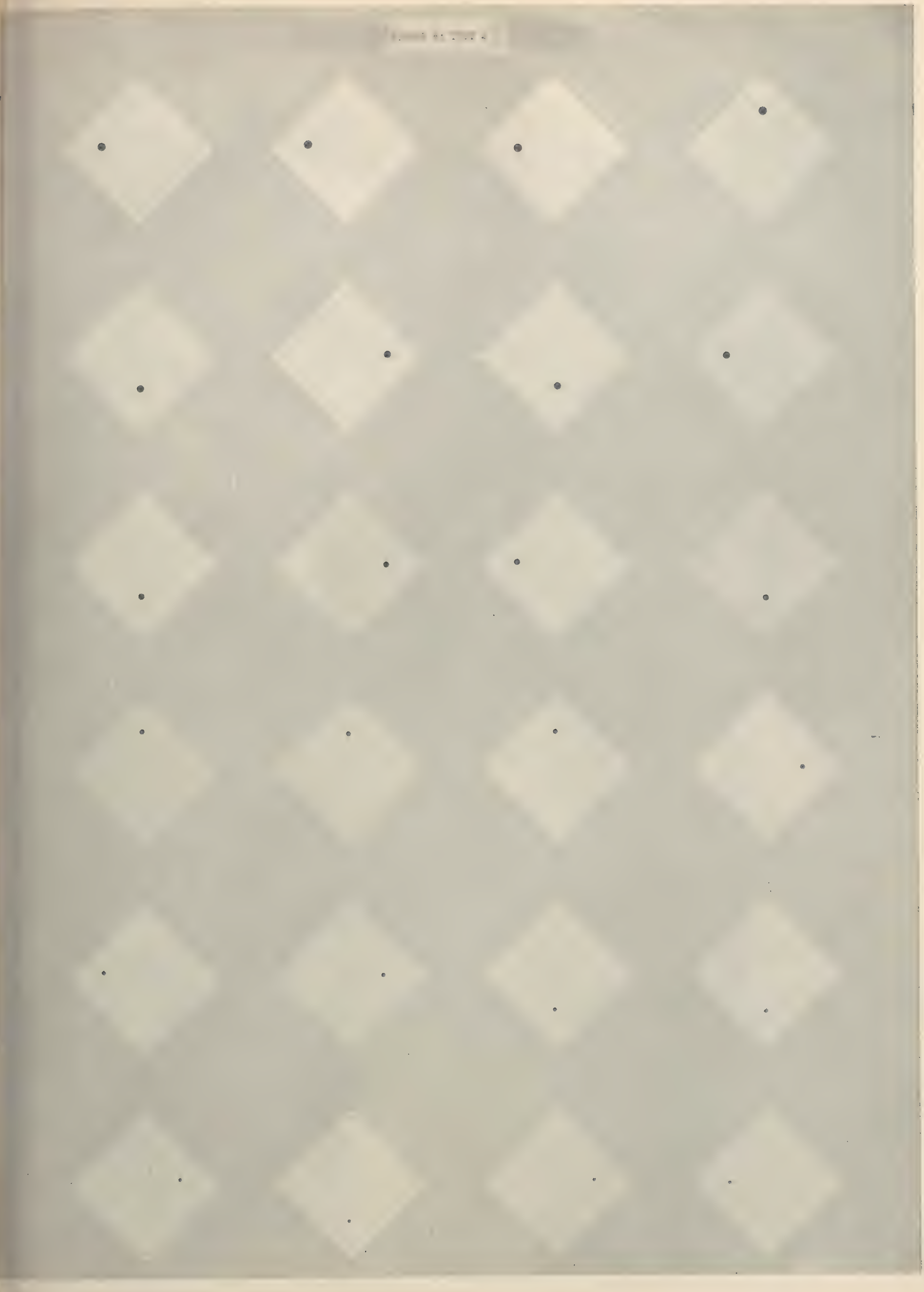


FIGURE 7; TEST 3

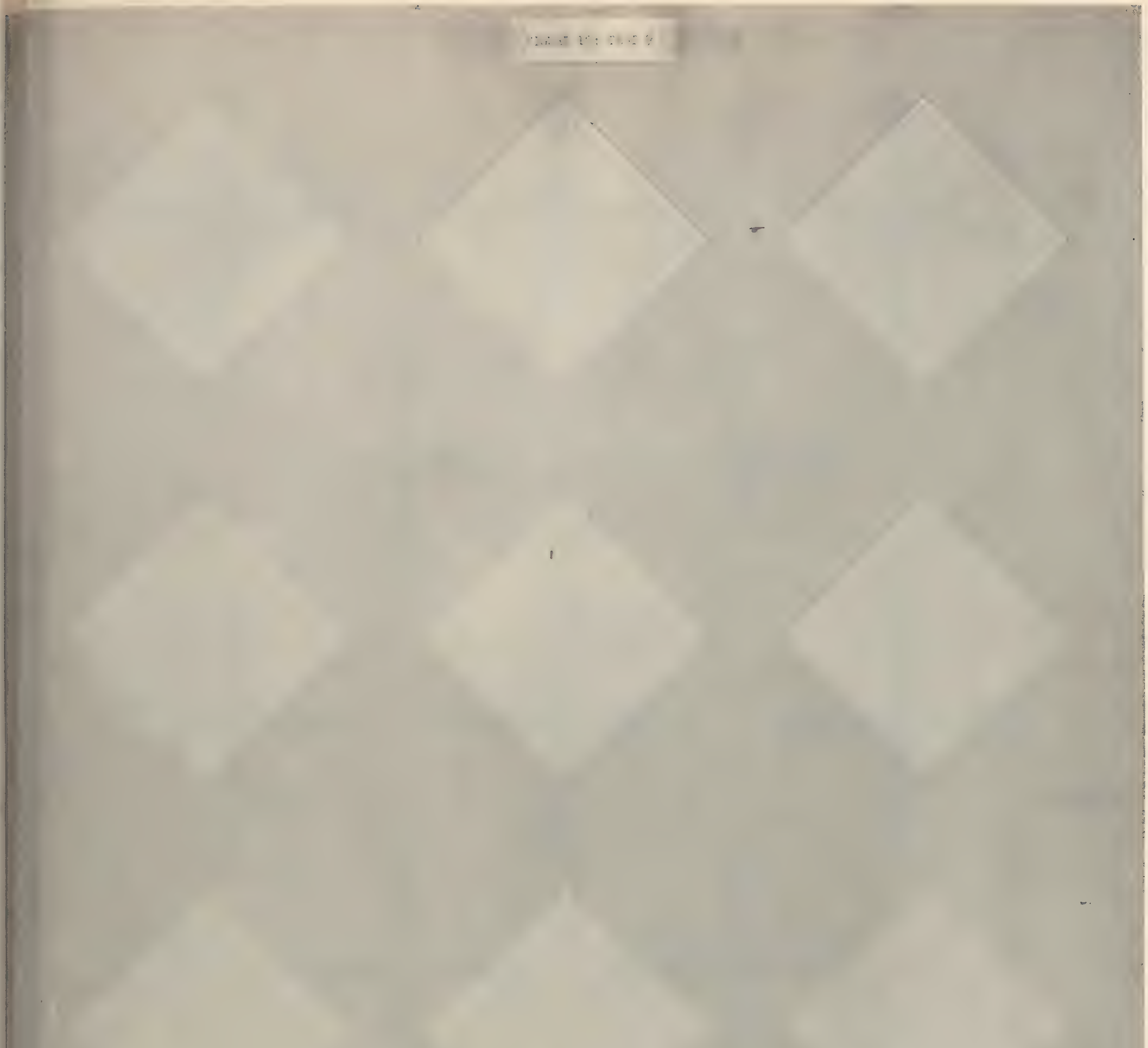


FIGURE 11; TEST 13

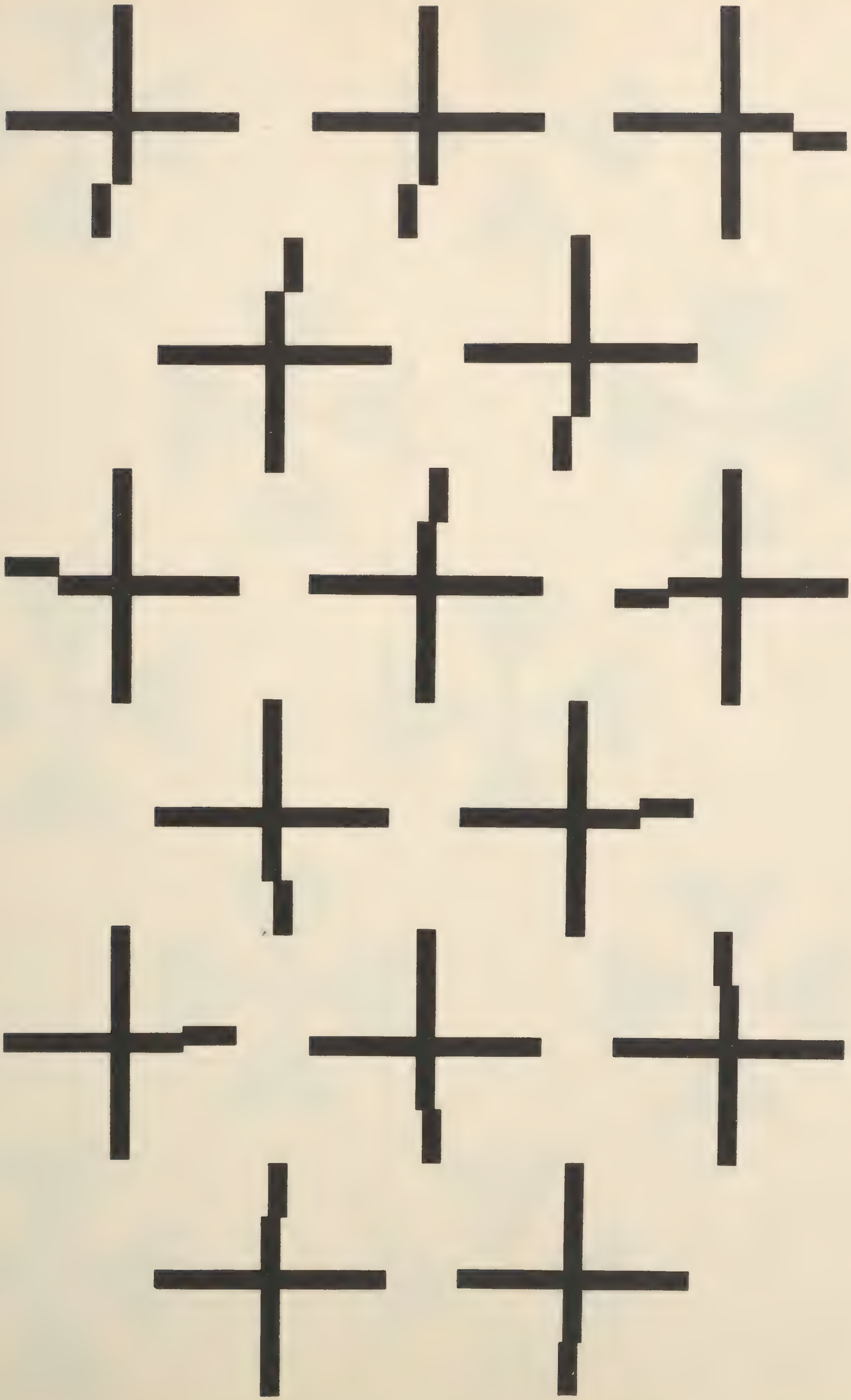
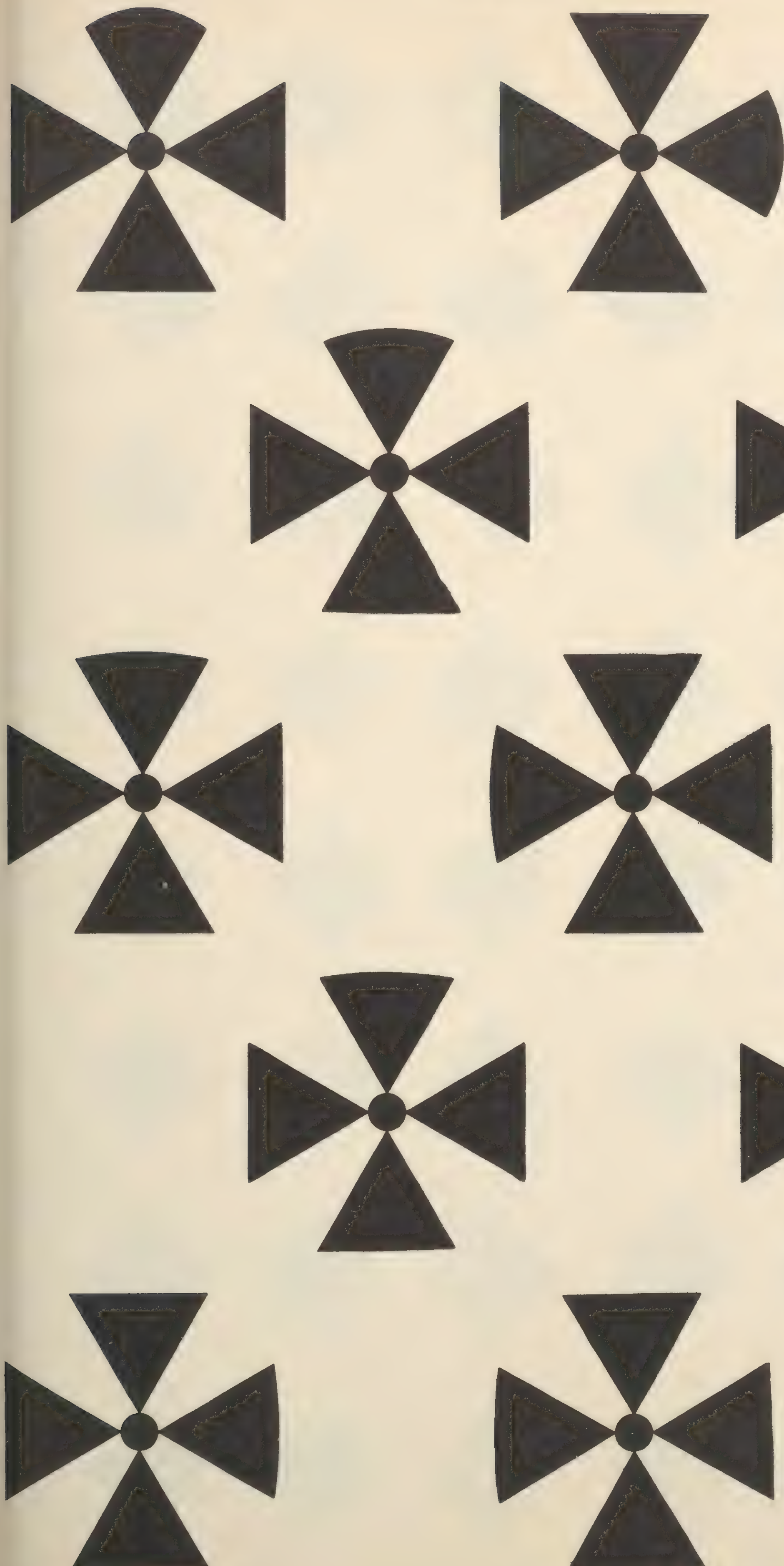


FIGURE 12; TEST 5



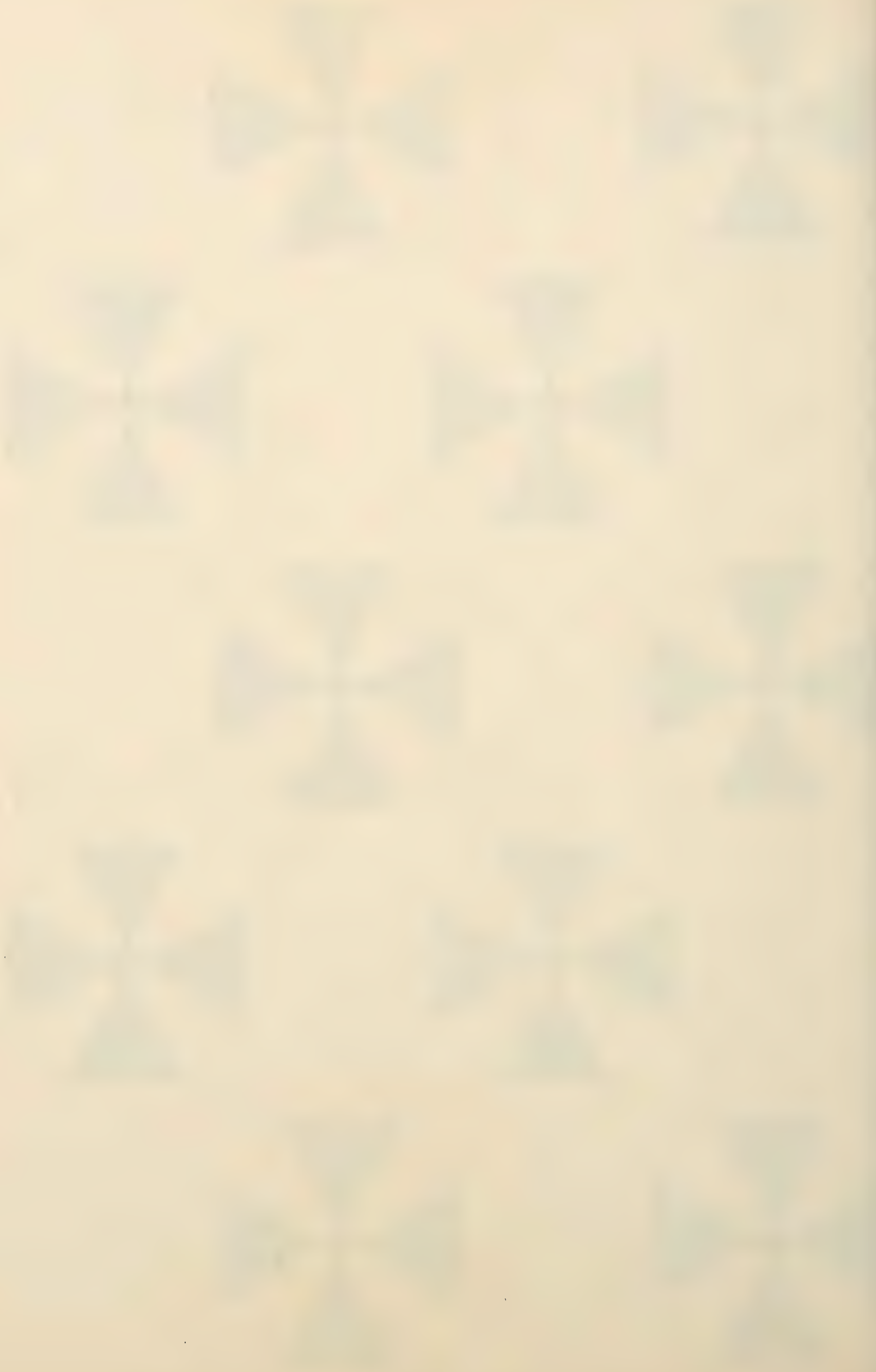


FIGURE 13; TEST 11

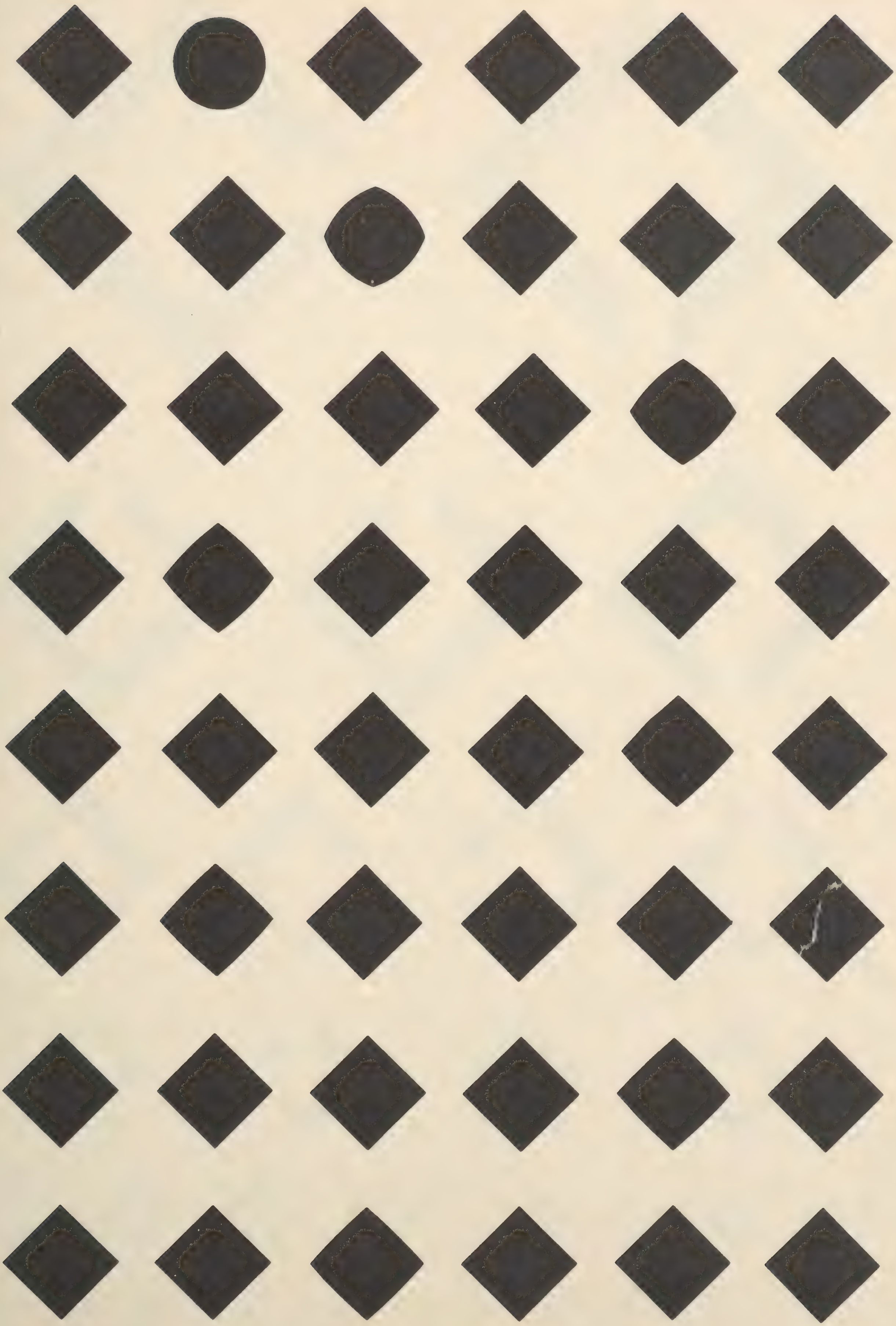
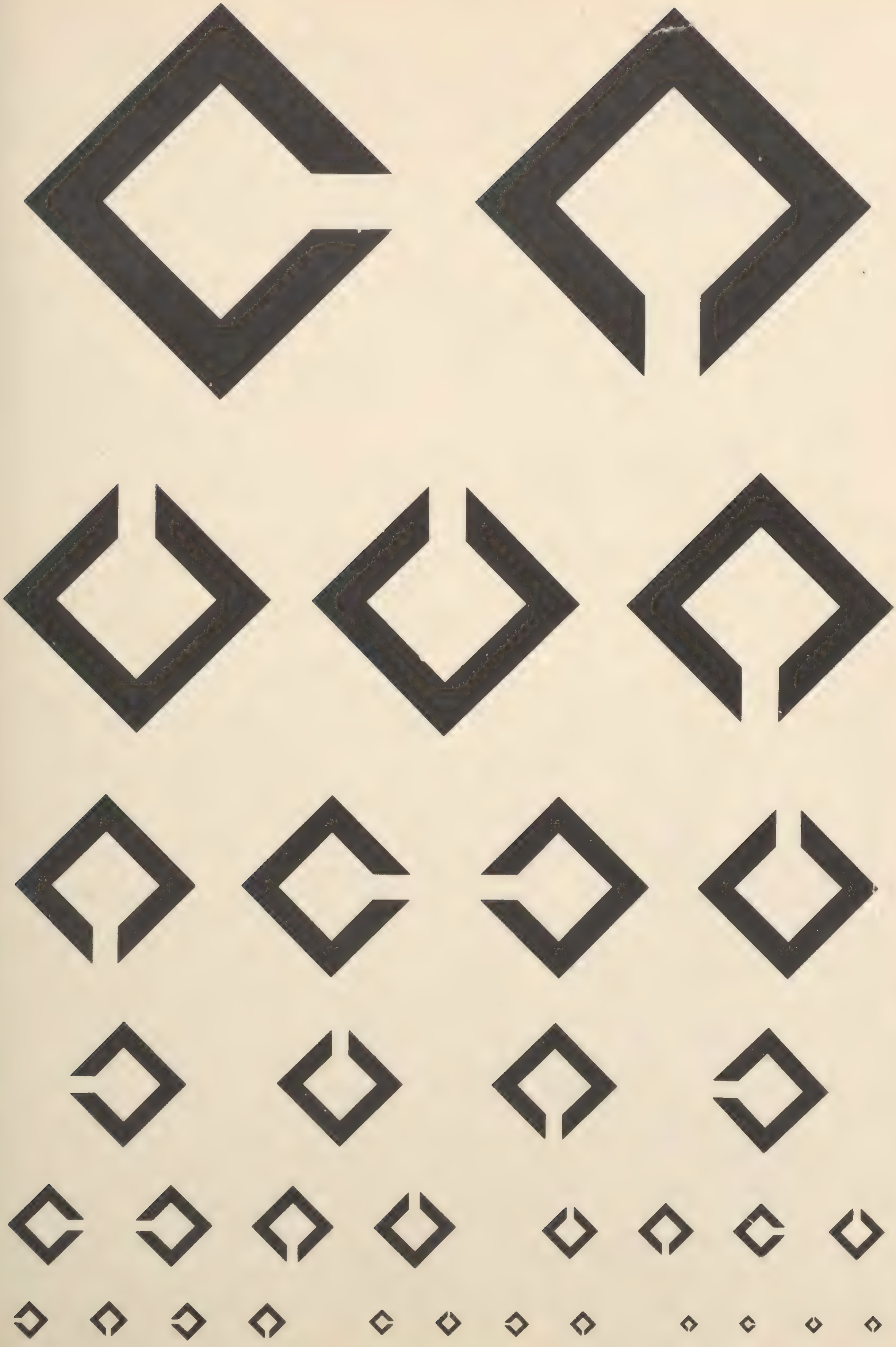


FIGURE 14



3. Scheduling Examinations. Examinations will be scheduled between the hours of 0800 and 1700. Under no circumstances will any examination take place after nightfall. Prepare Vision Examination Schedule, VES-1, in duplicate and provide for the following:

(a) Examination of each sample of enlisted men selected by above procedure within the following two days.

(b) Re-examination of first half of entire sample (approximately 200) not less than 18 nor more than 72 hours after first examination. (If necessary, arrange to hold over enlisted men for additional time to accomplish re-examination.)

(c) Equal daily workload for each Vision Examination Unit (about 6 to 8 examinations per day per Vision Examination Unit).

(d) Re-examination to be made by same examiner who conducted first test of enlisted man.

4. Data obtained on examinees:

(a) Name of examinee
(b) Army serial number
(c) Age on last birthday
(d) AGCT standard score
(e) Total number of school grades completed
(f) Station code
(g) Previous Snellen score (left eye only)
(h) Statement of examinee as to whether or not he wears glasses (other than sun glasses) and, if so, whether habitually or for reading only
(i) Estimated number of hours of rest in bed examinee had the previous night
(j) General health of examinee estimated by himself as "Excellent," "Good," "Average," or "Fair"
(k) Date and hour of test
(l) Indicate if first test or retest
(m) Question examinee upon having taken drugs within the last 24 hours. Record as indicated. The term "Drug" as used here does not include standard medication such as aspirin, but refers to opium, morphine, marijuana, belladonna, and to heavy drinking. If the examinee has taken any of these drugs or has been drinking heavily within the last 24 hours, dismiss him without examination. Explain that the drugs might affect his vision.
(n) Foot candle reading at center of blank white chart taken upon beginning of examiner's tour of duty.

CONFERENCE WITH EXAMINERS

At a conference between examiners and attendants and Committee members, an opportunity was given for obtaining opinions from the men actually responsible for the examinations. It was the general impression of Committee members that the enlisted men who served as examiners and attendants were alert, interested, and quite well-informed.

Perhaps the most important matter discussed was the motivation of the examinees. When asked whether the men seemed to do the best they could, the examiners replied in the affirmative. It was explained that the men had just entered the Army and, although told the test results would have no influence on their Army career, the men apparently did not want to take any chances on their performance.

The eagerness of the men gave rise to questions whether they manifested tension during the examination. The examiners reported some tension. They believed tension was greatest for the men with good vision at the beginning of the session but that with repeated successes, tension was diminished. Men with relatively poor vision, on the other hand, seemed to develop increased tension as their failures continued.

The general condition of the examinees was reported to be good. The examiners reported very few cases of severe loss of sleep, or excessive intake of alcohol. (They insisted that the beer available on the base was extremely weak, and that the men had to re-enter a long line for each additional bottle.) Apparently, few of the men tested had been subjected to prolonged K.P. duty the night previous.

The main difficulty encountered by the examiners was the tendency for examinees to skip items by accident on some tests. Letter charts were guilty in this respect, as was the square discrimination test. The examiners reported difficulty in explaining the form discrimination tests. It was reported also, that the letter Q on the New London letter test was often confused with C, especially when the letter was large. (Lt. Comdr. Farnsworth agreed that the same difficulty had been encountered at New London; he attributed it to carelessness on the part of examinees when the letters were easy.)

Examiners reported that the men preferred the letter charts. When pressed, they agreed that the men would probably not have much choice between a single letter chart and a single "forced-guess" chart. The test sequence, however, contains a high percentage of the latter type, which accordingly became monotonous.

Committee members expressed the opinion that the examinees should be told how many correct "guesses" they were capable of making during administration of the practice test. The real purpose of the practice test was to encourage the reporting of hunches, which would be accomplished best if the men were shown how often their hunches were correct. AGO personnel had not done this because they hoped to analyze the data of the practice test. Committee members recommended a change in this policy as soon as convenient.

NEEDS FOR VISION EXAMINATION IN THE ARMY

Colonel Lowrey discussed briefly the kind of eye examination now used in the Army. He listed fundiscopic examination and tests of: (1) visual acuity, for distance and for near; (2) muscle balance; (3) color vision; and (4) night vision. Because of the short time allowed the Army ophthalmologist for examination, job analyses for the various corps are needed so that the most pertinent tests can be made on each man. Colonel Lowrey emphasized that Army eye examinations will have to follow accepted civilian ophthalmological practice. For this reason, if new means of vision testing arise from the AGO vision testing program, they will need to gain general acceptance by ophthalmologists before the Army can use them.

Colonel Lowrey felt that the chief peacetime job in vision testing is to obtain complete information about the visual efficiency of the civilian population, so that proper assignments could be made in the event of hostilities. This plan emphasizes the need for reliable tests which isolate the various visual capacities and for job analyses and validations for the various military jobs.

NEEDS FOR VISION EXAMINATION IN THE AIR FORCES

Colonel Jennings remarked that the general needs for vision examination in the Air Forces paralleled those for the Army. Vision standards for pilots have been very stringent. In addition to a fundiscopic examination, tests have been used for (1) visual acuity; (2) stereoscopy; (3) color vision; (4) muscle balance; and (5) night vision. Colonel Jennings stated that the standards for flying non-commissioned personnel have not been so rigid.

In agreement with Colonel Lowrey, Colonel Jennings stressed the need for complete visual examination data on the civilian population. He expressed the belief that the Vision Committee might well aid in the collection of such data.

NEEDS FOR VISION EXAMINATION IN THE NAVY

Comdr. L. V. Julihn, USN

My remarks here will be based largely on my personal experiences of the past war which were confined solely to submarine operations. I have discussed these matters in some measure with officers who served on surface vessels, however, and I find that my comments apply as well for them and for the Navy in general.

In no previous war was it possible for a Navy to operate so freely at night and under conditions of low visibility as did the U. S. Navy during World War II. This was brought about chiefly by the development of radar and other electronic devices, and to a lesser extent by the splendid equipment and ships with which we were provided. The impact of electronic controls in the War and how it created innumerable problems in vision, and in ship construction as it relates to light-tightness, ventilation, and habitability, was enormous. For instance, on carriers I am informed that at first the men who manned the radars and those who were the lookouts were in entirely different divisions and watch sections of the ship. Enthusiasm became so great over the development of Combat Intelligence Centers, hereinafter called the CIC, where the information from the various radars was coordinated and fighter-director stations set up that the importance of the topside observers was momentarily overlooked. In a situation of attack by enemy planes the point is reached when the planes are close aboard or low over the water where radar is no longer effective. It is at this point that the need for a direct-vision, topside CIC suddenly became apparent. In other words the radars did all the "seeing" at relatively long ranges but the human eye finally had to do the "seeing" when the enemy planes broke through to press home their attacks. It appears that there were plenty of instances where the direct-vision CIC people called by radio to their own unseen combat air patrol or fighter above them to come down out of the clouds in a hurry and fend off the enemy planes coming in low over the water where only the human eye could detect them. I am informed also that a number of American pilots were destroyed by our own guns as they came screaming down from high altitudes to battle the enemy. It was not until an improved system of coordination between the ship's gunnery department and the fighter-director control was established that this situation was remedied.

The hangers of big carriers had to serve as the workshop where planes were serviced and kept in readiness for the pilots. This practice imposed long hours of night work under arc lamps for the maintenance crews. To make a hangar capable

of being converted into an open-air gallery during the day and yet be light-tight at night was a major construction achievement. I was told that the ESSEX when she first left her builder's yard had some two hundred light leaks which took several weeks to rectify.

This all leads up to the fact that night operations for surface ships imposed a light-tight requirement on personnel. This in turn often had to be balanced against habitability inasmuch as the closing up of a compartment meant poor ventilation, especially in the tropics. Poor ventilation resulted in a lowering of the crews' morale and efficiency due to enervating living conditions. The recent press release by the Navy Department divulging its plans to air condition all of its ships was based primarily on the facts I have presented here. Mere whim for the latest wrinkle did not govern this decision. It is now a matter of urgency to improve the habitability on board vessels while operating when sealed up for battle or at night in enemy waters. You probably know of course that in regard to U. S. Submarines air-conditioning helped to make possible the long patrols carried out by them. It obviously improved living conditions. What you may not know is that air-conditioning was an absolute necessity in submarines in order to keep the electrical equipment operating by minimizing the excessive sweating which goes on in a submerged vessel while in tropical waters.

The foregoing comments serve to emphasize the increasing vision problems due to night operations. I point out again that there are the indirect problems of vision fatigue due not only to the contrast of light and dark, but the reduced habitability conditions pursuant to dim lighting or the sealing of compartments to prevent light leaks.

Possibly nowhere-else in the Navy was the necessity for good vision and knowledge on such items as visual acuity, contrast sensitivity, or night vision so important as in the Submarine Service. This was especially true of course during the first two or three years of the conflict with Japan before radars had become an item of standard equipment. I was on board a submersible which had just been completed and shaken down shortly before the events at Pearl Harbor took place in December of 1941. As a consequence, I had an opportunity to observe the initial problems confronting submariners in particular, and of course the Navy generally. At first it was a matter of merely being able to work out a plan so that from the limited number of crew members in a submarine adequate lookout watches could be set up. During the days of peace, lookout duty was somewhat perfunctory as the officer of the deck was the only one who truly felt the responsibility of his task and there were rarely more than two lookouts in any event, one on either side of the bridge. As we moved into Japanese waters during our early patrols the responsibility which each lookout naturally felt for his personal safety quickly removed the former casualness of this work and a few quick dives with

enemy planes close aboard or torpedo wakes boiling at us made seasoned and reliable eyes out of the men who were on watch topside. The number of lookouts topside was dependent on the number of men which the commanding officer felt he could spare from duties elsewhere, and was limited by the time it took these men to get below before the ocean closed over the bridge hatch. It became standard practice to have anywhere from three to five lookouts topside although this often varied from night to day.

After the first six months of the war then the matter of establishing a lookout watch in sections became routine. Under varying conditions of visibility during all hours of the day and night it was soon apparent that regardless of the lookout's effort there were some who had eyes like hawks, others who could see better in the dark. There were of course additional personal factors; such as, men who could see but who could not articulate when they sighted something; or others who could not be broken of the day-dreaming habit no matter how many close shaves we had. I discovered, for instance, that all men became better lookouts when they learned "how to look." "How to look" includes a suitable method for holding binoculars so that the arms would not become excessively tired; how to sweep a sector of the horizon thoroughly; how to use binoculars at night in contrast to daytime operations. In any case, I learned that I had an especial skill for sighting the loom of land in the dark when others could not even see such things. At the same time this did not mean merely that I had better night vision for I was no better than many others when it came to seeing objects on the water or ships at night. As a matter of fact some myopia and slight astigmatism prevented me from being one of the really good daytime lookouts. Tied in with all of this was the gradual shift from four-hour peacetime watches to the two-hour wartime watches. This took place principally among the lookouts, but of course prevailed to a large degree with all of those topside whose business it was to be constantly on the alert for danger.

During those early months of the war the information about night adaptibility, night-lighting, etc., which came to us later was lacking. We kept the conning tower in a total blackout and lookouts were required to remain in that darkness for about fifteen or twenty minutes before coming topside to relieve. Gradually the red glasses, the red filters and the red bulbs were installed everywhere for night use.

These eased the former discomforts, and danger too, of a complete blackout. I remember the astonishment I experienced when the directives from the Navy Department began to appear on this subject indicating that red lighting was the least visible and least harmful to the night eye when formerly the weird blue lights for battle had been in vogue.

During the latter part of the war when we began to get all manner of radars on submarines, the job of the lookout was at the same time both simplified and complicated. I shall explain. Simplification was effected by the remarkable search and detection capabilities of the new equipment; thus giving the submarines additional security from surprise approach by the enemy. Our improved sonar equipment also brought this about in the same way, though to a lesser degree. Complication was added to the lookout's job from the fact that it was not only the electronic personnel who operated the new radars for there simply were not enough of them on board. It became general practice to rotate the lookouts through the conning-tower and thus give them a tour on the radars, or in some instances the sonar indicators. A new problem was added. Men began to complain of headaches after watching the radar screens for some time. Some of them complained so bitterly that it was necessary to eliminate the radar watch for them except in cases of emergency. Near the closing days of the war when submarines had as many as three or four radars plus electronic-frequency detection devices in operation, sometimes all at once, there was posed a huge problem to submariners, not alone from the limited number of personnel they could carry to handle all of these items, but from the eye fatigue factor which was becoming more and more pressing. From the fact that certain men complained of headaches while others were simply fatigued, it is possible that research in this channel would bring out some interesting facts which would render future operations of this sort more efficient and reliable from a personnel point of view.

While association during this most important phase of wartime submarining has caused me to emphasize the difficulties which attend lookout work from the visual acuity aspect, it should be pointed out that there are a number of other problems along these lines to which investigation might bring enormous returns. I refer to such things as instrument fatigue which constant reading of depth-gauge needles or the voltage and current indicators in the maneuvering room bring. There is the question of proper lighting in a submarine when people coming from topside in the bright sunlight find everything relatively dark or those same people during the black of night crash diving to man the depth controls under conditions that are either too bright or too dim. Time-motion studies have been made of the crowded conning-tower of a submarine while at battle stations, but the work which might be done toward determining better lighting, selection of operating personnel, color and character of instruments, is of great importance. I venture to say it is a field relatively untouched so rapid was our shift by the circumstances of this war into electronic control methods characterized by the combat intelligence centers now an integral part of every combatant vessel.

I am not sure that this is an appropriate time to bring up this matter but I shall venture it as of possible concern to this gathering. I am reminded of the strict eye requirements of all the services. I believe the entrance requirements at the military academies are especially exacting. I know that during the war, however, there were officers in submarires whose eyes had deteriorated to a point where under ordinary circumstances they would not have been permitted to be retained on duty. Yet they did their jobs efficiently and well. I have heard a comment to this effect from these people which may have been uttered with considerable levity but also impresses the hearer with a certain note of logic, "It sure seems funny to me. The Navy apparently is willing to have you risk your life in wartime, but yet you're not good enough for the peacetime Navy when operating conditions are much less exacting." Undoubtedly this matter has been given considerable thought by those to whom such things in the services are entrusted. I believe also there is room for some eye classification far beyond that now practiced which should permit officers and men of proven intellect and ability to pursue a service career, including duty at sea. In submarine work especially where the direct unaided eye is rarely used because of periscopes, binoculars, icaroscopes, radar screens, and sonar indicators I think the eye requirements wisely might be altered considerably.

Discussion of the "needs" in Army, Air Forces, and Navy:

Colonel Kirsten expressed the idea that visual selection was a matter of supply and demand. All other aspects of a candidate being equal, the one with better vision should be selected. When the supply is relatively low, as in wartime, eye waivers are possible.

Comdr. Julihn point out that if visual standards could be lowered, other standards could be made more stringent, even in peacetime when the supply of candidates is large.

Dr. Baier stated that he believed physical fitness had been overemphasized in service selection programs.

INTEREST OF THE BUREAU OF NAVAL PERSONNEL IN VISUAL ACUITY TESTING

The basic interest of the Bureau of Naval Personnel in problems of visual acuity lies in the field of personnel classification. We need to know what individual differences in visual performance must be taken into account in assigning personnel, for what duties in the Navy these differences are important, and what standards of visual performance should be specified for appropriate assignments.

We hope, therefore, that research in vision will yield the following four results:

1. the construction of visual tests of sufficient reliability for use in classification work, as opposed to survey or general screening purposes.

2. equipment and procedures which attain this desired reliability together with administrative ease and economy.

3. validity data showing the kind and degree of relationship between various visual tests and performance on naval jobs.

4. visual standards for naval assignments established so as to facilitate the best possible use of available manpower.

The use of visual tests for classification purposes demands, in general, more reliable measures than those satisfactory for survey or screening. Classification involves utilizing fairly small differences within a restricted group. Personnel with very low acuity have already been rejected before they reach the classification stage, so that it is not a question of whether a man has 20/20 or 2/20 acuity, but whether he has 20/20 or 18/20. If the small differences are not practically important, then there is no need for a classification type of visual test. If, however, these variations among men who all have acceptable vision really determine proficiency on the job, tests of considerable precision are needed. With unreliable tests considerable numbers of men whose visual acuity is really too low for satisfactory performance will pass the test because they happened by good luck to meet the cutting score. Similarly, many men whose vision is really satisfactory will be rejected because they had bad luck in taking the test. Good classification minimizes the role of luck.

There are two common types of visual acuity tests, neither of which is completely satisfactory in reliability. The familiar wall chart can yield precision results under closely controlled laboratory conditions of illumination intensity, glare, chart surface, etc. Under operating conditions variations from station to station and from time to time at the same station can be expected, with resulting low reliability. The instrument type of test, such as the Telebinocular, Orthorater, and Sightscreener, uses a series of targets of decreasing size with four possible answers on each target. The reliability of this type of test is limited by the fact that there is only one target for each level of acuity and only four choices for each target. This means that of all the people who can really only see target number 9, one-fourth will obtain a score of 10 by chance, and one-fourth of those again will score 11 by chance. This variation itself is sufficient to lower the reliability of these tests to barely acceptable limits when homogeneous groups are involved.

It is to be hoped that further research on visual acuity tests will develop measures which will combine the standardized conditions of the enclosed instrument with a larger number of stimuli in the range in which cutting scores are likely to be set. At the same time, testing time and administrative procedures must be such that the use of the test is practicable.

The validity problem is probably the most formidable aspect of visual research from the classification point of view. So far as the visual test itself is concerned, it is not yet certain which of several types of test object measures the kind of visual acuity required on the job, nor is it known which billets require good near vision and which good far vision. More generally, it is not known for which billets any visual acuity tests will predict success closely. It is not sufficient to determine by a job analysis that the billet involves visual acuity; the degree of association between success in the billet and visual test scores must be measured.

With many tests it can be safely assumed that the higher the test score the higher the performance on the billet, on through the entire range of test scores. With visual acuity it is very likely that this simple linear relationship does not hold, and that acuity above a certain level produces no corresponding increase in job performance. This phenomenon serves to make research more difficult, because enough people must be studied just above and just below the point of diminishing returns to permit stable conclusions.

The actual use of visual acuity tests in classification work involves the establishment of standards or cutting scores. In this connection it must be noted that, with a limited supply of manpower available, any standard or specification imposed is at the expense of some other standard. If too high standards

of visual performance are specified, personnel deficient in some other requirement must be assigned. The problem is to set the visual requirements in conjunction with other qualifications so that the correct balance is obtained. Statistically, this is likely to involve a problem in multiple curvilinear regression, necessitating ample and well-planned study. The setting of standards in visual tests without a realistic realization of their consequences is likely to produce the results reported in one study in which over 60% of experienced combat gunners failed to pass the visual standards prescribed for their billets.

The discussion above has been oriented in terms of acuity tests. The needs of the Bureau of Naval Personnel are similar and governed by similar considerations in the case of stereopsis, heterophoria, and color vision.

METHODS OF STANDARDIZING ILLUMINATION UTILIZED IN THE RESEARCH PROGRAM

Mr. Karlin described the precautions taken to insure a reasonable standardization of illumination on the test charts at Fort Dix. Photometric measurements were made twice daily on the test charts in each of the test rooms with a Macbeth Illuminometer. In addition, checks were made with a G. E. exposure meter to standardize the brightnesses of the walls of the test rooms. It was apparent that adequate precautions had been taken to insure that variations in the brightness of the test rooms was not an experimental variable.

PRELIMINARY INDICATIONS FROM AVAILABLE DATA

Dr. Corbin discussed the data obtained at Fort Dix during two weeks of experimentation. While additional data will undoubtedly change the conclusions reached, general indications were unmistakable even so early in the data collection. Charts were shown of the distributions of scores on each of the test charts. Some tests were clearly too difficult for the population tested. Others showed distributions of scores with considerable skewness.

Test-retest reliabilities were computed on each chart and are presented below. (46 subjects).

TEST	r_{tt}	M_I	M_{II}	σ_I	σ_{II}
Practice	.93	23	23	7.8	8.6
Test 1. Army Snellen	.94	27	28	12.7	12.0
Test 2. Dot Variable Size	.91	19	20	12.0	11.1
Test 3. Quadrant Variable Contrast	.73	5	5	2.4	2.5
Test 4. New London Letter	.93	30	32	18.8	18.9
Test 5. Triangle Discrimination	.82	11	12	5.6	5.6
Test 6. Bausch and Lomb Checkerboard	.77	12	13	7.2	7.0
Test 7. AAF Letter	.87	27	28	16.8	16.2
Test 8. Line Resolution	.90	32	33	13.7	14.6
Test 9. Dot Variable Contrast	.29	4	4	2.1	2.1
Test 10. AAF Constant Decrement	.89	20	20	10.5	10.4
Test 11. Square Discrimination	.44	7	7	3.5	3.8
Test 12. Checkerboard Variable Grid	.87	14	15	8.2	8.4
Test 13. Vernier Acuity	.69	19	20	7.5	7.1

	TEST	M	σ	P	1	2	3	4	5	6	7	8	9	10	11	12	13
	Practice	22.64	7.71														
1.	Army Snellen	27.61	13.49	.84													
2.	Dot Variable Size	20.14	11.40	.81	.90												
3.	Quadrant Variable Contrast	4.98	2.21	.64	.66	.67											
4.	New London Letter	29.09	16.21	.78	.89	.86	.59										
5.	Triangle Discrimination	10.68	6.14	.61	.65	.68	.48	.83									
6.	Bausch & Lomb Checkerboard	11.64	6.48	.75	.87	.86	.61	.83	.63								
7.	AAF Letter	27.78	16.78	.80	.92	.88	.66	.90	.80	.82							
8.	Line Resolution	33.12	13.82	.82	.89	.88	.74	.82	.68	.83	.85						
9.	Dot Variable Contrast	3.75	2.07	.50	.69	.53	.48	.46	.32	.43	.46	.55					
10.	AAF Constant Decrement	20.52	10.25	.83	.94	.88	.68	.90	.83	.83	.92	.88	.66				
11.	Square Discrimination	6.42	3.37	.53	.63	.51	.40	.46	.46	.51	.54	.53	.29	.53			
12.	Checkerboard Variable Grid	13.91	7.51	.75	.83	.84	.63	.81	.60	.82	.81	.80	.44	.84	.49		
13.	Vernier Acuity	20.33	6.90	.78	.85	.80	.69	.76	.61	.75	.80	.85	.53	.84	.53	.74	

It is apparent that all tests except the square discrimination and the dot variable contrast show satisfactory reliability. Intercorrelations between the various tests are shown above. (180 subjects)

It is interesting to analyze the intercorrelations with respect to the five types of visual capacities which were supposedly measured. The intercorrelations between the letter charts were:

Army Snellen:	Test 1
New London Letter:	Test 4
AAF Letter:	Test 7
AAF Constant Decrement:	Test 10

Tests	Intercorrelation
1-4	.89
1-7	.92
1-10	.94
4-7	.90
4-10	.90
7-10	.92
average	.91

RESTRICTED

Intercorrelations between the four resolution tests are as follows:

Dot Variable Size:	Test 2
B and L Checkerboard:	Test 6
Line Resolution:	Test 8
Checkerboard Variable Grid:	Test 12

Tests	Intercorrelations	
2-6	.86	
2-8	.88	
2-12	.84	
6-8	.83	
6-12	.82	
8-12	.80	
	average	.84

It is interesting to analyse intercorrelations between letter charts and resolution tests, since letter charts were originally designed to be tests of resolution.

Tests	Intercorrelations	
1-2	.90	
1-6	.87	
1-8	.89	
1-12	.83	
4-2	.86	
4-6	.82	
4-8	.82	
4-12	.81	
7-2	.88	
7-6	.82	
7-8	.86	
7-12	.81	
10-2	.88	
10-6	.83	
10-8	.88	
10-12	.84	
	average	.85

Intercorrelation between the contrast sensitivity tests is only .48, although this is probably explicable by the low reliability of the Dot Variable Contrast test.

Intercorrelation between the form discrimination tests is only .46 which likewise is probably explicable by the low reliability of the Square Discrimination test.

165. Comparison and Evaluation of American Optical Co. Pseudo-isochromatic Plates First and Second Editions.
John H. Sulzman
Medical Research Department, U.S. Submarine Base, New London, Connecticut.
First and Final Report on BuMed X-480 (Av-255-p), 16 July 1945, 16 pp. (O).

"From the result of the present experiment in which two editions of the American Optical Company's 'Pseudo-Isochromatic Plates for Testing Color Perception' were administered to 200 individuals of the U. S. Navy, the following conclusions are drawn:

"1. Personnel showing hesitancy or difficulty with the first edition showed hesitancy with the second edition.

"2. Known color weak persons were detected by use of the second edition but some individuals were designated as color-weak who passed the requirements for color perception according to present Navy standards by the use of the first edition.

"3. There are indications that the new test is probably more difficult to memorize.

"4. Most of the medical officers consulted agree that the new edition is decidedly easier to administer.

"5. The second edition shows a greater disparity than the first edition both in the number of failures among plates of the same group, and among the groups themselves.

"6. Artificial daylight illumination gives superior performance in the selection of color weak individuals."

166. Comparative Reaction Times to Christmas Tree Signal Lights with Respect to Color Deficiency.
Dean Farnsworth and John David Reed
Medical Research Department, U.S. Submarine Base, New London, Conn.
Color Vision Report No. 10, N.L. Sub-1-CV-10, BuMed X-265 (Av-153-c), 5 February 1945, 11 pp. (O)

"1. A submarine hull opening indicator board, commonly called the 'Christmas Tree', was wired so that observers' reaction times to the red and green light signals could be measured.

"2. A group of four color blinds was compared with a group of six color normals to determine the difference in mean reaction times when the lights were at full brightness. 450 trials were given each man. Slight difference was found between the two groups.

"3. As a control, the same two groups were tested on the same apparatus for reaction time to position. They proved to be comparable in this respect.

"4. When on patrol the lamps are customarily burned on reduced voltage. To approximate the appearance of a dimmed board, the green jewel was changed slightly in color by the addition of a yellow filter. Two color blinds and two men with normal color vision were tested on this. The change in color greatly lengthened the reaction time of the color blinds but not of the normals.

"5. It is concluded that color blind individuals are able to read the Christmas Tree at full brightness nearly as rapidly as normals. As the voltage supplying the lamps in the Christmas Tree is dropped, the color blind may be expected to show progressively greater hesitancy in discriminating the red from the green jewels.

"6. The use of bluish-green glasses would be expected to decrease the confusion effect for color blinds."

167. A Study of the Physiological Blind-spot of the Dark-adapted Fovea.
J. H. Sulzman
Medical Research Department, U.S. Submarine Base, New London, Conn.
Progress Report No. 1 on BuMed Project X-423 (Av-262-p) BuMed Project X-614 (Av-316-k), 1 March 1946. 22 pp. (C).

"The results of an experiment administered to 24 men of the U. S. Navy appear to indicate that:

"1. The Livingston method of rod scotometry is too exacting in technique, and too demanding in terms of fatigue and co-operation of subjects to be of great value as a screening test for night vision. However, it has undoubted value in capable hands as a reliable confirmatory measure for doubtful cases, and possibly, as a diagnostic aid. Its correlation with the Radium Plaque Adaptometer at varying distance seems to be satisfactory.

"2. While the Korb Diaphragm Shutter Scotometer at the present time is not as reliable as other tests, it has the following advantages: (a) it is simple to operate and to be comprehended, (b) it can be administered with some rapidity, and (c) the data obtained agree very well with the results from the Livingston test."

"Certain mechanical difficulties with this device can be remedied.

"Its correlation with the Radium Plaque Adaptometer appears to correspond with that of the Livingston test.

"3. The Radium Plaque Adaptometer at five feet distance seems to provide a satisfactory measure of night vision on a pass-fail classification. Pearson coefficients of reliability and intercorrelation for this small population are adequate.

"4. The Radium Plaque Adaptometer at seven feet distance seems to provide a wider classification of night vision than the prescribed procedure at a distance of five feet. From the data of the present experiment, the seven-foot technic appears to be slightly more reliable. There is little indication that test results at seven feet correlate well with scotometric measures."

168. A Brief History of Lanterns for Testing Color Sensation and Description of the Essential Principles.
Dean Farnsworth and Priscilla Foreman
Medical Research Department, U.S. Submarine Base, New London, Conn.
Preliminary Report on Development and Trial of New London Navy Lantern as a Selection Test for Serviceable Color Vision, BuMed X-457 (Av-241-k), 15 April 1946. 12 pp. (C)

"A brief description is given of lanterns which have received official acceptance for testing color vision of naval and maritime personnel: Edridge-Green, devised in 1891; Williams, 1902; Board of Trade, 1912; Martin's Board of Trade Modification, 1938, and Transport Type, 1943; Royal Canadian Navy, 1941; and Royal Canadian Air Force, 1945.

"Three psycho-physical features of the lantern type test were found to be of chief diagnostic value: (1) small color apertures in order to test central color vision, (2) brightness contrast of paired colors, and (3) red, white, and green colors in a color blindness confusion zone.

"Mechanical features which were found to promote efficient testing were: (1) one aperture size, (2) one-hand operation, (3) operation from any side, (4) rising-front stand, (5) use in a light room, (6) exposure and occlusion of lights, (7) sufficient weight for stability, (8) aperture indicators and (9) a long-life lamp.

"Mechanical features which were found necessary to standardization of the test were: (1) non-interchangeable lamps, (2) permanent color standards, (3) reproducible color filters within manufacturing tolerances and (4) testing instructions attached to lamp."

189. Development and Trial of New London Navy Lantern as a Selection Test for Serviceable Color Vision.
Dean Farnsworth and Priscilla Foreman
Medical Research Department, U.S. Submarine Base, New London, Conn.
Color Vision Report No. 12, N.L. Sub-1-CV-16, BuMed X-457 (Av-241-k), 6 May 1946, 39 pp. (0)

"1. A color vision testing lantern was designed which was intended to be as quick and convenient to give as pseudo-isochromatic plates or other standard tests, which would be more reliable in its pass-fail criterion and less dependent upon the training and personal interpretation of the examiner. A model of the proposed Navy Lantern, called the New London Prototype Model, has been tested on over 2000 individuals and compared with other standard tests for color vision.

"2. This experiment indicates that the new model has the advantages of other official lanterns and has overcome their observed deficiencies. It is designed for extreme ease and simplicity of operation and convenience of upkeep. It may be operated from the back or either side, it permits one-hand operation, and it is heavy enough to maintain a fixed position during operation. The glass color standards are permanent and reproducible, the lamp is sturdy and long-lived, the lights are exposed and occluded by the same knob which changes the color combination, the aperture indicators are plainly evident to the operator, one standard aperture size is used, and the instructions are attached to the lamp.

"3. Out of a population in which 10% failed the pseudo-isochromatic plates, only 8% failed the lantern. The 2% not failed by the lantern represent the "borderline" defectives who are not considered dangerous in Naval service.

"4. The test is quickly administered. A test on a normal, including instruction, is completed within one-half minute.

"5. The Navy Lantern is similar in level of difficulty to other standard lanterns.

"6. The test-retest reliability of the lantern is extremely high. Coefficients of correlation are .95 and over.

"7. Men who are definitely color defective by the criterion of other tests consistently fail the lantern. Conversely, no color-normal will be classified as possibly defective by the lantern.

"8. There is evidence that performance on the lantern will correlate with color recognition at sea.

"9. The lantern has face validity which is convincing to examiner and examinee alike.

"10. It is more difficult to "coach" or "train" a man to pass the lantern than to coach him to pass pseudo-isochromatic plates.

"11. The recommended colored filters are specific indicators of degree of color defectiveness in red to green sensitivity.

"12. The lantern specifications are believed to represent the most efficient instrument for testing color vision of Naval personnel."

170. Evaluation of the "Contrast Discrimination Test" as an Anoxia Demonstration Device.
A. Chapanis
A.A.F.-ATSC. Engineering Division, Aero Medical Laboratory
Serial No. TSEAA-695-65, 1 March 1946, 19 pp. (0)

"The purposes of this report are:

a. To evaluate the Contrast Discrimination Test, Model II, devised by S. Hecht, C. D. Hendley, S. Shlaer, and S. Frank for demonstrating the effects of anoxia on vision; and

b. To compare the Contrast Discrimination Test, Model II, with the Luckiesh-Moss-Army Air Forces Anoxia Demonstration Chart, Type AAF-1, from the standpoint of their usefulness and effectiveness as anoxia demonstration devices.

"The Luckiesh-Moss-Army Air Forces Anoxia Demonstration Chart, Type AAF-1, is a more satisfactory anoxia demonstration device than the Contrast Discrimination Test, Model II, for the following reasons: the ADC is cheaper, easier to explain and administer, requires less time to administer, and convinces more indoctrinees of the effects of anoxia than does the CDT."

171. Optical Distortion in Airplane Windshields.
H. K. Hartline and D. Scott, Jr.
Johnson Research Foundation, University of Pennsylvania
Navy Project TED No. 25115, Contract OEMcrm 209, November, 1945, 46 pp. (0)

"1. A study has been made to examine and evaluate the distortion which is present when the visual scene is viewed through the transparent panes of an airplane windshield. For this purpose distortion is defined as the disturbance of the spatial relations of details in the visual scene and does not include the loss of clarity of the scene due to poor optical quality of the panes.

"2. The theory of optical distortion has been partially developed in which the deviation of light rays traversing a transparent pane has been expressed as a function of (a) the amount of wedge of the pane, (b) the amount of curvature of the pane, and (c) the angle of incidence. Deviation causes points in the visual scene to appear displaced; variation of the apparent displacement is distortion. Calculation of distortion has been made for several types of transparent panes.

"3. Transparent panes can introduce spurious binocular parallax, causing distortion of the stereoscopic view, and impairing depth perception.

"4. The following enclosure panes were studied: (1) Windshield assemblies from F6F, TBF, SBD-5, and F4U airplanes, (2) Two unmounted and unidentified cylindrical glass panes, (3) Several flat glass panes from windshields of PB2Y airplanes which were considered defective in operation.

"5. The optical distortion was measured and analysed for views through the windshields typically used in flight. It was found that distortion was largely due to the use of strongly curved panes at high angles of incidence and was therefore greatest in the F6F, SBD, and F4U windshields. The amount of wedge found to be present in all panes was small and contributed only slightly to the total distortion.

"6. Comparison of glass and plastic panes showed that there is no preference for one material rather than the other so far as optical distortion is concerned. Where distortion is present, the fault is in the design of the windshield; not in the choice of the material.

"7. The effects which distortion may be expected to have on flying are discussed in terms of decreased performance and increased hazard and pilot fatigue. The fact that airplanes are flown successfully in spite of large amounts of distortion does not prove that the effects are negligible but only that personnel can partially compensate for them.

"8. Suggestions are made for investigating means of reducing optical distortion and devising quantitative inspection methods.

"9. Tolerances are suggested for allowable amount of distortion.

"10. Suggestions are made for further work to provide a sound basis for controlling optical distortion."

[redacted]

MEETING OF SUBCOMMITTEE ON VISUAL EXAMINATIONS

A meeting of the Subcommittee on Visual Examinations was held November 15, 1946, at Personnel Research Section, AGO, New York. The following were present:

Dr. Derrick T. Vail, Chairman
Dr. Franklyn Burger
Col. Victor A. Byrnes, Randolph Field, Texas
Lt. Comdr. Ellsworth B. Cook
Lt. Comdr. Dean Farnsworth
Dr. Henry A. Imus
Col. Austin Lowrey, Jr., Walter Reed Hospital, Wash. D.C.
Dr. Richard Scobee
Dr. Donald G. Marquis
Mr. H. Richard Blackwell
Dr. Donald E. Baier, Personnel Research Section, AGO
Dr. J. B. Carroll, " " " "
Dr. Horace H. Corbin, " " " "
Dr. E. D. Cureton, " " " "
Dr. Douglas Fryer, " " " "
Mr. Lawrence Karlin, " " " "
Dr. Erwin K. Taylor, " " " "
Dr. Robert Wherry, " " " "

Dr. Douglas Dryer described the purpose of the meeting as an evaluation of the results of the completed experimental run at Fort Dix and determination of the design of the next phase of the program.

Dr. Erwin R. Taylor discussed in some detail the reliabilities and intercorrelations of the 14 tests. Following Dr. Taylor's report the group discussed the method of scoring used in evaluating the test results. On 261 cases for each of the 14 tests, the following six scoring methods were used:

A. Number of rights to the first miss.
B. Number of rights to the first miss plus the total number of attempts.
C. Number of rights to 2 consecutive misses.
D. Number of attempts to 2 consecutive misses.
E. Number of attempts up to the first point following which 3 of 4 items are missed.
F. Line number after which at least 50% of the items are missed. (Not used for tests 3, 5, 9, 10, 11 and 13.)

Correlation matrices indicated that the six scoring techniques yielded essentially equivalent results. Intercorrelations between the various methods of scoring were very high. Test-retest reliability was discussed for each of the tests for each of the six scoring methods. In general, there was very little difference in the reliability for the various scoring methods.

[redacted]

A discussion concerning the desirability of the various scoring techniques used revealed that the most obvious scoring method was not one of the six used. This scoring method is based upon the number of correct responses made during the entire test. Since each test was continued until three successive errors were made, it is desirable to devise a scoring method in which all of the data are used on each test. Because some of the tests are of a constant decrement form, whereas others employ lines in which the test objects are of equal difficulty, a scoring method should be devised which is equivalent for the two types of test structure. Since there are only four items in a line, where the items in a line are of equivalent difficulty, a criterion of three consecutive misses means that the test was continued until the level of chance response was reached. This is also true in the case of constant decrement charts so that when all correct responses up to the three consecutive misses are included in this score, equivalent scores are obtained for the two kinds of tests. It was recommended by the Subcommittee that in the future all of the data from the program be scored in this way, rather than by any of the other six scoring methods.

Although the data presented by AGO were not expressed in terms of the preferred scoring method, it seemed apparent that the interrelations between various tests and the reliability of tests would not be significantly different regardless of scoring method. Consequently, the group discussed next the question of the reliability of the fourteen tests.

It was apparent from analysis of Table I below that in most cases the tests were sufficiently reliable for feasible application. The tests having the lowest reliability, tests 3, 5, 9, 11, were examined on the histogram plots of the frequencies of scores from which it was obvious that an insufficient number of items were present in these tests for satisfactory reliability. Accordingly, Spearman-Brown predictions were made concerning the reliability to be expected with twice the number of items. These data are presented in Table II below, together with the reliabilities of the tests as administered.

TABLE I - RELIABILITIES

TEST	SCORING METHOD A	B	C	D	E	F	METHOD ADOPTED
Practice Test	.60	.76	.80	.76	.75	.74	C
1. Army Snellen	.69	.84	.82	.78	.83	.80	C
2. Dot Variable Size	.84	.86	.88	.85	.92	.85	C
3. Quadrant Variable Contrast	.58	.54	.59	.53	.41	.--	A
4. New London Letter	.69	.84	.84	.81	.83	.85	C
5. Triangle Discrimination	.68	.73	.72	.65	.66	--	A
6. Bausch and Lomb Checkerboard	.79	.80	.81	.76	.75	.76	C
7. AAF Letter	.78	.87	.89	.85	.88	.87	C
8. Line Resolution	.75	.84	.86	.83	.83	.83	C
9. Dot Variable Contrast	.49	.45	.40	.32	.30	--	A
10. AAF Constant Decrement	.72	.83	.84	.82	.84	--	C
11. Square Discrimination	.42	.42	.43	.37	.33	--	A
12. Checkerboard Variable Grid	.84	.82	.85	.81	.76	.83	C
13. Vernier Acuity	.74	.80	.76	.69	.73	--	C

TABLE II - RELIABILITIES (Scoring Method C)

Test Number	Test as Administered	2 N Items
3	.59	.74
5	.72	.84
9	.40	.57
11	.43	.60

It is apparent from these data that satisfactory reliability can be obtained by doubling the number of items in these tests. In Table I, the method of scoring upon which the additional statistical analyses were done is indicated. Because of the small differences between the various scoring methods it is not considered significant that the preferred scoring method was not used in the different tests or that different scoring methods were used in the several tests.

Dr. Wherry presented the results of a factor analysis. If one of the axes of a rotation plot was made to run through the checkerboard resolution tests, the other axis apparently represented contrast sensitivity. The quadrant variable contrast and the dot variable contrast tests had maximum values on the contrast sensitivity axis but they also had a definite weighting on the resolution axis. The letter charts were weighted approximately as high on the resolution axis as the checkerboard tests, but were displaced slightly on the contrast sensitivity axis. Other tests fell in between these extremes.

On another diagram, the triangle and square discrimination tests were maximized on an axis at right angles to the resolution axis. On this graph the contrast sensitivity tests fell on the resolution axis.

It is impossible to report all the results and possible interpretations which can be made from the diagrams. Certain indications, however, are rather clear. In the first place, letter charts are very similar to checkerboard resolution charts, with a small weighting on another perameter which might be called form discrimination. As expected, the contrast sensitivity tests measured principally what they were designed to measure, but with loadings on the resolution perameter. Again, as expected, form discrimination tests were shown to belong principally to another perameter than either resolution or brightness discrimination.

The possibility was discussed that the factor diagrams should be constructed so that the axes ran through the contrast discrimination charts. It can be argued that contrast discrimination is the fundamental visual function; all other discriminatory functions are, in the final analyses, resolvable to it. If such an hypothesis were true, the factor diagrams

would indicate that no resolution test was independent of this factor, as expected. Form discrimination tests show a separate factor in accordance with expectation.

The Subcommittee considered its recommendations to the AGO research staff concerning the future direction of the research. It seemed clear that future experimentation should include the following kinds of tests:

(1) A checkerboard resolution test.
(2) A letter test.
(3) A contrast discrimination test.
(4) A form discrimination test.

The checkerboard variable grid test appears to be an adequate instrument for measuring checkerboard resolution. Either the New London letter or the AAF constant decrement appears to be an adequate measuring instrument. (Selection should be determined on the basis of item analysis.) Of the two contrast discrimination tests, the more satisfactory appears to be the quadrant variable contrast. Because of its low reliability, it is necessary that the test be lengthened and perhaps modified in other respects. Of the two form discrimination tests, the triangle discrimination is the more satisfactory, but it should also be lengthened to increase reliability.

From the discussion which followed, it appeared advisable that in addition to these three tests, a test be developed for measuring vernier acuity. The present test appears to be more a form discrimination test than a vernier acuity test since the examinees respond to the cross as a configuration rather than to the break in one arm of the cross. Discussion of various kinds of vernier acuity tests produced several suggestions which will be developed by the AGO staff. It was the opinion of various members of the AGO staff that the dot variable size test should be continued in the battery for further testing. It was thought possible that this test might prove a joint measure of contrast discrimination and resolution if indeed two separate functions exist. Such a joint weighting seemed indicated by the factor analysis although other experimental evidence does not seem to justify this conclusion.

It was decided before the next experimental runs with the improved test charts, preliminary experiments might be conducted to determine optimal conditions of test chart presentation. It seems desirable to determine the relative efficiency of constant decrement and line charts. It is possible that simplified conditions of presentation could be evolved which would be more readily duplicable at various experimental stations where future tests will be made.